

Neurobehavioral Consequences of Traumatic Brain Injury

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Abstract

At least 1.4 million people die, or receive hospital or emergency care every year in the United States as a result of traumatic brain injury (TBI). Many more are treated in other settings or receive no treatment at all. Thus TBI is often unidentified, with subsequent cognitive, behavioral, emotional and physical sequelae that are not linked to the injury. Yet, over 5.3 million Americans live with TBI-related disabilities that interfere with their overall performance and social roles within the community. The pathophysiology and consequences of TBI are discussed, as are functional changes and psychiatric manifestations after TBI. Finally, implications and recommendations for clinical practice are reviewed, including the importance of screening for TBI.

Key Words: Traumatic brain injury, neuropsychiatry, rehabilitation, axis I disorders, psychiatric disorders.

Introduction

TRAUMATIC BRAIN INJURY is the leading cause of death and lifelong disability in the United States for individuals below the age of 45. Current estimates from the Center for Disease Control (CDC) indicate that at least 1.4 million Americans sustain a TBI annually (1). Of these individuals approximately 235,000 are hospitalized, 50,000 die, and 1.1 million are treated and released from emergency departments. Approximately 90,000 are left with permanent disabilities each year (1). As a result, more than 5.3 million people, approximately 2% of the U.S. population, and about 57 million world-wide, are living with disabilities secondary to their brain injury (1, 2). While these numbers are large, the CDC acknowledges that these figures are actually an underestimate of the actual number

of people living with TBI, because the data only include individuals who die or obtain medical services in hospitals and emergency departments. Typically, these are individuals who have sustained a documented loss of consciousness (LOC) or a period of confusion or altered mental status, and in some instances, have positive neuroimaging findings (i.e., computed tomography [CT], magnetic resonance imaging [MRI]) (1). A majority of individuals do not exhibit neuropathology on neuroimaging after TBI (3) and, often, the report of the duration of LOC or post-injury confusion is uncertain, particularly if there were no witnesses to the event precipitating the TBI. CDC incidence figures do not include people treated in federal, military, or VA hospitals, or the estimated 528,000 individuals with TBI who were treated in physicians' offices (439,000) or in outpatient settings (89,000) (4). People who do not seek medical attention are also not included; this represents a number estimated to be equal to 25% of the number of individuals with mild or moderate TBI (5). Given that a majority of TBIs are mild, this number is likely to be several hundred thousand each year. In many instances, no link is made between the blow to the head the person sustained and subsequent physical, cognitive, behavioral or emotional sequelae. TBI has been called the "silent" or "hidden" epidemic because many individuals are

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The preparation of this manuscript was supported in part by Grant Nos. H133A020501 and H133B040033 from the National Institute on Disability and Rehabilitation Research, U.S. Department of Education.

not identified by the health care system and their neurological, neuropsychological and neurobehavioral symptoms and functional difficulties are attributed to etiologies other than brain injury (6–11).

The consequences of TBI are often devastating to the individual and their loved ones. Significant physical impairments often occur, including headaches, sleep problems, fatigue, blurred vision, dizziness, loss of hearing, and in a small percentage of cases, seizure disorders (12, 13). Even more prevalent are changes in cognitive, behavioral and emotional functioning. Cognitive complaints are typically reported in the areas of memory, attention, and executive functioning (14). Additionally, increased irritability, depression or anxiety is often reported by individuals who suffered from a traumatic brain injury, or identified by those close to the person (15). Behavioral changes may include the presence of impulsive behavior, reduced frustration tolerance, lack of empathy, emotional lability, apathy or aggression. This variety of symptoms is often not associated with the TBI by the individual, his or her family, or primary health care providers, particularly when the subject has experienced a “mild” TBI or “concussion” (16, 17). This lack of identification can lead to no treatment or to inappropriate treatment (18–20).

Consequences of Injury

TBI severity is defined by the duration of LOC, altered mental status (e.g., confusion) or post-traumatic amnesia (PTA) (21). It is important to note, however, that the severity of functional impairments after TBI often is not related to the severity of the injury (21, 22). Patients are classified as having a moderate-to-severe TBI if they have a LOC over 30 minutes or altered mental status greater than 24 hours or Glasgow Coma Score below 12 (16, 21). Although many individuals who experience a moderate-to-severe injury have some functional impairments after the injury, they usually receive inpatient, and possibly outpatient, rehabilitation services to address these impairments. However, this is rarely the case with individuals who sustain a mild TBI. Mild TBI is defined as a blow to the head followed by a LOC of less than 30 minutes, an altered mental status with PTA of less than 24 hours or Glasgow Coma Scale score of 13–15 (16). In fact, many professionals mistakenly assume that individuals who experience a mild TBI will make a full recovery of functioning within a brief period of time (16, 17). For a majority of those with a mild TBI, this assumption is warranted and full recovery occurs within 3–6

months (23, 24); however, a significant minority, approximately 15%, will continue to experience long-term cognitive, physical and behavioral difficulties that interfere with their ability to function (25–30). This condition is also known as Persistent Post-Concussion Syndrome (PCS) (12, 25, 31). Despite its counterintuitive name, “mild” TBI can result in significant post-injury impairment (22). Because these consequences are not well understood, family members and many professionals may assume that these individuals are exaggerating their symptoms or “faking” (32, 33). As a result, emotional or behavioral problems are seen as psychogenic (34, 35). However, as noted above, the symptoms are most likely secondary to neurological event and not primarily psychiatric (36).

Etiology of TBI

TBI results from an external force applied to the skull (including inertial force), leading to temporary or permanent pathology. While direct, focal injuries can occur as the brain makes contact with the sharp bony surfaces of the skull, a majority of TBIs result in widespread shearing and stretching of nerve fibers (diffuse axonal injury) caused by the rapid acceleration and deceleration of the brain. The diffuse nature of the injury contributes to a broad range of symptoms, including impairments in arousal, attention, mood, and behavior. The frontal and temporal lobes are common sites of damage that may lead to disruption of the closely linked limbic system thought to be involved in the modulation of emotional, motivational, and behavioral processing (33, 37).

Until recently, most TBIs were the result of motor vehicle accidents (MVAs), but the CDC's most recent report (1) reveals that falls are currently the leading cause of TBI, with rates highest for children under 4 and adults over 75 years of age. MVAs are second, with physical assaults and sports-related injuries accounting for a majority of the remaining TBIs reported each year.

Functional Changes

The severity of the injury is not necessarily associated with the extent of the person's functional impairments (3, 22) and post-TBI functioning is multifactorial. Physical changes reported by individuals after brain injury may vary and can be independent of the severity of the TBI. Symptoms may include: fatigue, clumsiness, decreased sensory functioning (i.e., changes in hearing, vision, smell and taste), dizziness, changes in appetite, seizures, and difficulties with sleep and tempera-

ture regulation (38, 39). Sensory loss has been reported as long as ten years after TBI (40), with impairments of smell (41) and hearing (40) being most commonly reported. Fatigue, described as exhaustion after simple and routine physical or mental tasks (42–44), is one of the most common physical symptoms reported after TBI. This problem is often complicated by disruptions in the sleep cycle. Lack of sleep and daytime sleepiness can further impair cognition, behavior and mood, and can undermine treatment. Additionally, chronic pain (45) and headaches, in particular, commonly follow even mild brain injury (44–46) and can interfere with cognitive functioning.

Cognitive problems following TBI include impaired attention and concentration, reduced processing speed, word finding difficulties, altered academic abilities (i.e., errors in simple math computation, spelling difficulties, and difficulties understanding what one reads) decreased memory and learning abilities, and impaired executive functioning (i.e., reduced ability to plan, sequence, prioritize, think flexibly, abstract or problem solve) (14, 38). Since a high percentage of individuals with TBI sustain damage to the frontal lobes or to the frontal system, impairments of higher level thinking or executive functioning are common (33, 37). In addition to executive dysfunction, memory problems are almost always present following TBI, either due to direct effects on memory systems or secondary to disrupted attention and concentration (33, 47–51). Often, the severity of cognitive deficits does not become apparent until the individual tries to resume the activities of pre-injury life, such as return to work (52).

Besides physical and cognitive symptoms, many individuals with TBI experience various types of behavioral dyscontrol (e.g., impulsivity, aggression, amotivation, apathy) and emotional dysregulation (e.g., moodiness, irritability, apathy) (53), which can disrupt the individual's social interactions and employability (38, 54–56). Impaired interpersonal communication and social cognition (e.g., an inability to follow conversations, being rude, interrupting people, talking too fast or too slowly) also impact the person's ability to develop and maintain meaningful relationships (57).

Co-occurring Psychiatric Diagnoses

In addition to physical, cognitive and behavioral changes that occur following TBI, a majority of individuals with TBI are diagnosed with one or more newly acquired psychiatric diagnoses after injury (15, 58). Alterations in mood can arise as the individual with TBI recognizes that the impair-

ments associated with the injury have not resolved. Individuals often describe changes in the self and loss of defining personal attributes. These changes can lead to feelings of depression or anxiety (59). This realization is often compounded by description of the individual by friends and family as a "different person." Although emotional distress, most commonly in the form of depression and anxiety, is the most prevalent psychiatric disorder for many individuals immediately after injury, some resolution in psychological symptoms typically occurs over time. However, longitudinal studies have suggested that a substantial proportion of individuals with TBI either continue to experience or develop late-onset psychiatric disorders (60) for as long as 30 years after injury (61).

Major depression is the most prevalent psychiatric disorder after injury, with estimated rates ranging from 14–77% (13, 15, 58, 61–66), with approximately 60% meeting a diagnosis of depression at some point after injury (67) and about 20% at any given time after TBI (58). Other frequent psychiatric disorders after injury include substance abuse, ranging from 5–28% (58, 64, 66), post-traumatic stress disorder (PTSD), with prevalence rates ranging from 3–27% (15, 58, 64, 65, 68), other anxiety disorders, which affect from 3–28% of persons with TBI (15, 58, 62, 64–66, 69) and personality disorders (70). Sampling (community vs. clinical settings) and measurement variability may account for the different prevalence rates reported across studies (71). However, regardless of the methods used to sample, these rates remain consistently higher than in the general population (13, 15, 58, 61, 62, 64–66). While the risk for developing psychiatric symptoms is highest in the first year following injury (58, 66), the risk for developing these disorders remains elevated for decades after TBI (61, 65, 72). Furthermore, these disorders are often comorbid. Depression and anxiety are especially likely to co-occur with substance abuse (13, 58, 64, 66, 73).

The development of psychiatric disorders following TBI, particularly the comorbidity of psychiatric disorders and substance abuse, can increase the risk of other neurobehavioral problems, often creating obstacles for reintegration into the community (71, 74). For example, individuals who have experienced a loss of consciousness are four times more likely to attempt suicide than those who have not (69). Additionally, Simpson and Tate (73) reported that co-morbid depression and substance abuse in individuals with TBI increased the risk of suicide twenty-one times. Thus the comorbidity of axis I disorder significantly increases suicidality. While numerous neurobiological (i.e., in-

jury-related) and psychosocial factors contribute to the development and persistence of psychiatric disorders after TBI (75), factors such as length of time since injury, severity of injury, duration of LOC, age, gender, years of education, and ethnicity have not been found to be predictive of who develops psychiatric disorders after TBI (13, 15, 58, 62, 63, 65). However, pre-morbid psychiatric history, in particular, pre-existing personality disorders, has been associated with having a greater risk for developing additional psychiatric disorders after injury (15, 58, 61).

Implications for Clinical Practice

Consistent screening for TBI is important, especially in practices involving populations where "hidden TBI" is known or suspected to be common. This includes psychiatric populations (including substance abuse), individuals routinely exposed to violence (domestic violence), athletes and the elderly. Detailed histories should be taken to identify instances of blows to the head resulting in LOC, PTA, or altered mental status. These may be numerous and may have occurred weeks, months, or years prior to the current encounter with the health care system. When such events are identified, it is important to determine whether they predate the onset of presenting, potentially TBI-related symptoms.

Negotiating the health care system presents individuals with TBI and health care practitioners with a variety of challenges. Cognitive deficits may make it difficult for individuals with TBI to participate actively in maintaining their health and managing their own health care. Monitoring their health status and health problems and communicating with the representatives of the health care system can become burdens that the person with TBI is unable to cope with without some degree of assistance. Even when primary care providers and specialists spend significant time with these individuals, the cognitive deficits can still create barriers to effective treatment. The impact of these limitations is that the health care of the individual with TBI is often compromised.

Attention impairments can make it difficult to remain focused in interactions with health care staff. Filling out long checklists or forms can also be difficult with attention and concentration problems. Doing two activities simultaneously like providing one's medical history while being examined may be particularly challenging. Memory impairments in the individual with TBI can impact health care treatment because of difficulty in remembering details of one's medical and medication his-

tory, remembering topics to discuss with the health care provider or specific documentation to bring to appointments, and difficulty following through with prescribed interventions and medications. Reductions in processing speed can make it difficult to take in and respond to new information. Individuals with TBI may need to have additional time to complete forms and checklists, process health care information, and plan health care options. Executive dysfunction can affect the ability to plan health care, organize treatment appointments and follow-up care, prioritize information, remain focused and "on topic," regulate emotional responses (e.g., withdrawal, anger) if the individual becomes frustrated during interactions with the health care system. The person may feel easily overwhelmed and accompanying fatigue, embarrassment or humiliation can lead to avoidance of health care providers and failure to follow through with treatment. Health care practitioners need to recognize, anticipate, and accommodate these difficulties when dealing with patients with TBI.

Cognitive remediation is a recommended evidence-based intervention (76–78) for addressing the numerous cognitive sequelae of TBI. It is effective in managing specific domains of cognitive deficit such as attention and memory problems as well as improving functional and vocational outcomes and community integration (76–78). Remediation can thus help persons with TBI in negotiating the health care system more effectively. When possible, individuals with TBI should have a neuropsychological evaluation to determine the nature and extent of the cognitive impairments and plan treatment. Remediation, which may be coupled with psychotherapy, can then be provided by rehabilitation psychologists or neuropsychologists, in conjunction with speech therapists, occupational therapists, and other rehabilitation professionals.

Conventional wisdom and clinical reports indicate that psychopharmacology can be effective in treating neurobehavioral symptoms after TBI (79), including behavioral dyscontrol (e.g., aggression, irritability) and emotional turmoil (e.g., depression, anxiety). There is some evidence that depression after TBI is amenable to pharmacologic intervention, alleviating not only the mood disturbance but also reducing other physical (e.g., fatigue, headache) and cognitive symptoms (e.g., inattention, poor concentration) (80). However, it is essential to start medications with low doses, possibly sub-therapeutic, and titrate the medication slowly with continuous reassessment of symptoms because of high susceptibility to adverse effects for individuals with TBI (79). Medications that are highly sedative or have deleterious effects on the

central nervous system also should be avoided for similar reasons (79, 81), including further memory impairment. Frequent reassessment is also necessary to assure that the individual remembers to take the medication, monitor side effects and treatment efficacy, especially since there are very few well-controlled studies examining the efficacy of various commonly used medications (78).

Consultation with a neuropsychiatrist familiar with the evaluation and treatment of psychiatric disorders following TBI may be of benefit to persons with TBI, their families, and clinicians providing care. Additionally, cognitive remediation and psychotherapy also can be instrumental in addressing changes in identity after TBI and improving emotional disturbances (e.g., depression, anxiety) (78, 82).

Conclusion

The high prevalence of TBI suggests the need for clinicians to consistently screen for TBI, particularly due to the large number of unidentified cases. Having knowledge of an individual is important, especially in practices involving populations where "hidden TBI" is known or suspected to be common. General practitioners should be aware of the possible long-term sequelae of TBI in order to provide appropriate education to individuals with TBI (83–85). In addition, the large number of possible co-morbid conditions following TBI may require a multidisciplinary approach to address symptoms such as headaches, sleep disorders, sensory disturbances (e.g., blurred vision, loss of hearing, imbalance), or seizures. It is critical to understand the link between common features of TBI and the common neuropsychiatric sequelae of brain injury, to adequately evaluate the individual with TBI (83, 86). Appropriate educational and neuropsychological intervention is critical to ensure positive outcomes, especially over the first year or two after injury. Explaining the possible neurocognitive and neurobehavioral sequelae and recovery pattern for TBI to the individual and involved caregivers can maximize recovery and effective treatment plans (85). The primary care physician can play a major role in monitoring progress and intervention, and in maximizing an improved outcome.

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